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NASA TECH BRIEF

Lewis Research Center

New Nickel-Base Wrought Superalloy With Applications Up to 1253 K (1800°F)

A new nickel-base wrought superalloy designated NASA IIB-11 has been formulated which has higher temperature use capability than advanced alloys currently used for gas turbine engine disks. The alloy possesses a combination of high tensile strength at low and intermediate temperatures to 1033 K (1400°F) with good rupture strength at high temperatures to 1255 K (1800°F).

The alloy has a composition in weight percent of: 0.13 carbon, 9.0 chromium, 9.0 cobalt, 2.0 molybdenum, 7.5 tungsten, 7.0 tantalum, 4.5 aluminum, 0.75 titanium, 0.02 boron, 0.10 zirconium, 0.50 vanadium, and 1.0 hafnium, with the balance nickel. Its calculated density is 8.74 g/cm^3 (0.316 lb/in^3).

The alloy has been evaluated in a solution treated and aged condition. After hot working, the alloy was solution treated at 1490 K (2225°F) and given intermediate and final aging treatments at 1144 and 1033 K (1600 and 1400°F), respectively. In this condition, it has 0.2% yield strengths of 1190, 1080 and 490 MN/m^2 (173,000, 157,000 and 71,000 psi) at room temperature, 1030 and 1260 K (1400 and 1800°F), respectively. Its stress rupture life is 500 hours at 1033 K and 620 MN/m^2 (1400°F and 90,000 psi), and 60 hours at 1255 K and 172 MN/m^2 (1800°F and 25,000 psi).

Alloy IIB-11 has considerable promise for turbine disk application in future gas turbine engines which will use directionally solidified eutectic blades to permit higher turbine inlet temperatures than in current engines. Its rupture strength is as high as that of advanced cast turbine blade alloys up to temperatures of about 1033 K (1400°F).

Alloy IIB-11 is also a candidate for a wrought integrally bladed turbine wheel since its rupture strength at temperatures up to 1255 K (1800°F) is as high as cast alloys commonly used for integral wheels. Also, because its low and intermediate strength is considerably greater than that of the most advanced cast alloys, the thickness, and therefore the weight, of the disk portion of the wheel could be reduced.

IIB-11 was first produced as a conventionally cast and wrought alloy. It was extruded to break up the ingot structure and then hot rolled. Without the high-temperature solution heat treatment, it exhibited superplastic behavior at 1255 K (1800°F). Thus, it should be possible to produce an integrally bladed wheel close to final dimensions by isothermal pressing at low strain rates. The full solution heat treatment would then be applied to produce the alloy's high temperature strength.

In a current NASA development program, disk blanks are being produced from prealloyed powder of the IIB-11 composition and three slightly modified compositions. These have been designed to improve their microstructural stability after exposures to temperatures around 1144 K (1600°F). Analysis of the electron vacancy concentration (N_v) of the seventeen IIB modifications tested for stability shows that the N_v of the IIB-11 composition is only slightly above the stability limit in this alloy family. Thus, it appears that small modifications will make the alloy stable. Also, the application of prealloyed powder technology should contribute to the ease of forming the alloy by superplastic pressing.

Notes:

1. A similar alloy, IIB-7 (see Tech Brief 74-10002), but with 10% tantalum and 3.5% aluminum, has higher tensile strength up to 1033 K (1400°F) but lower rupture strength at 1033 K (1400°F) and above than IIB-11.
2. Further information is available in the following report:

   NASA CR-120934 (N72-26441), Development Study of Compositions for Advanced Wrought Nickel-Base Superalloys

   Copies may be obtained at cost from:

   Aerospace Research Applications Center
   Indiana University
   400 East Seventh Street
   Bloomington, Indiana 47401
   Telephone: 812-337-7833
   Reference: B74-10003

(continued overleaf)

3. Specific technical questions may be directed to:
    Technology Utilization Officer
    Lewis Research Center
    21000 Brookpark Road
    Cleveland, Ohio 44135
    Reference: B74-10003

Patent Status:

NASA has decided not to apply for a patent.

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Lewis Research Center, and
R.V. Miner, Jr., F.H. Harf, and
S.G. Young
Lewis Research Center
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